



RCA INSTITUTES

INC.
formerly
MARCONI INSTITUTE
Founded 1909



Technical Lesson 58

ARC TRANSMITTERS

Federal Arc Transmitters. The standard arc transmitters manufactured by the Federal Telegraph Company are based upon the method of obtaining radio frequency oscillations by means of an electric arc. The arc is enclosed in a chamber with an atmosphere containing hydrogen and the electrodes are placed between the poles of a powerful electromagnet, which produces a strong transverse magnetic field tending to blow the arc out. Carbon or graphite is used for the negative electrode, while the positive is made of copper, and water cooled.

The arc transmitter shown in Figures 1 and 1A consist of the following main units:

- (1) A Source of Direct Current of Suitable Voltage.
- (2) An Arc Converter.
- (3) An Antenna Loading Inductor.
- (4) An Antenna and Ground System.
- (5) A Signal Device.
- (6) Auxiliary and Control Apparatus.

The essential features of such a transmitter and the main circuits are outlined in Figure 2. The arc converts the power supplied by the direct current generator into radio frequency energy with undamped current in the antenna circuit. The antenna circuit includes the antenna, the loading inductor, the electrodes of the arc, and the ground system. The choke coil prevents the flow of radio frequency current from the arc back into the power machinery and serve to sustain and steady the arc itself. The frequency of the undamped current in the antenna circuit depends upon the inductance and capacitance of this circuit. The frequency and therefore the wavelength may be altered by changing the value of either the inductance or the capacitance, or both. Since the capacitance is furnished by the antenna and is, therefore fixed, the inductance of the circuit is varied in making changes of wavelength. This is accomplished by changing the connections to the antenna loading inductor.

In electric power practice rotary converters are used to convert alternating current of 60 cycles, or other commercial frequencies, into direct current. In the field of radio communication arc converters are used to convert direct current into alternating current of very high frequency,--for example, 60,000 cycles. The rotary converter, however, involves heavy rotating parts, commutators, etc., while the arc converter is a stationary machine. All parts of an arc converter are stationary except the carbon electrode, which is rotated very slowly in order that it may burn evenly, and which is made so that it may be screwed in and out in order to strike and adjust the arc. In operation, the length of the arc flame is adjusted to secure maximum antenna current and

"Back Shunt" Method of Signaling. The essential units of this method of signaling are:

- (1) The Back Shunt Circuit.
- (2) The Back Shunt Relay Key.
- (3) The Morse Hand Key.

The circuits employed for sets equipped with the back shunt method of signaling are outlined in Figure 3. When the movable contact of the back shunt relay key presses against the stationary contact which is connected to the bottom of the antenna loading inductor, the radio frequency current flows in the antenna circuit. When the movable contact presses against the other stationary contact, the radio frequency current flows in the back shunt circuit and there is no current in the antenna because it is then disconnected from the arc. The relay key is adjusted so the movable contact makes connection with one stationary contact before it breaks with the other. This permits the arc to remain in constant operation while being transferred from the antenna circuit to the back shunt circuit.

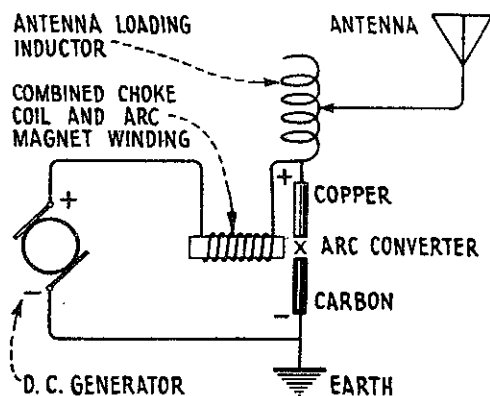


Figure 2

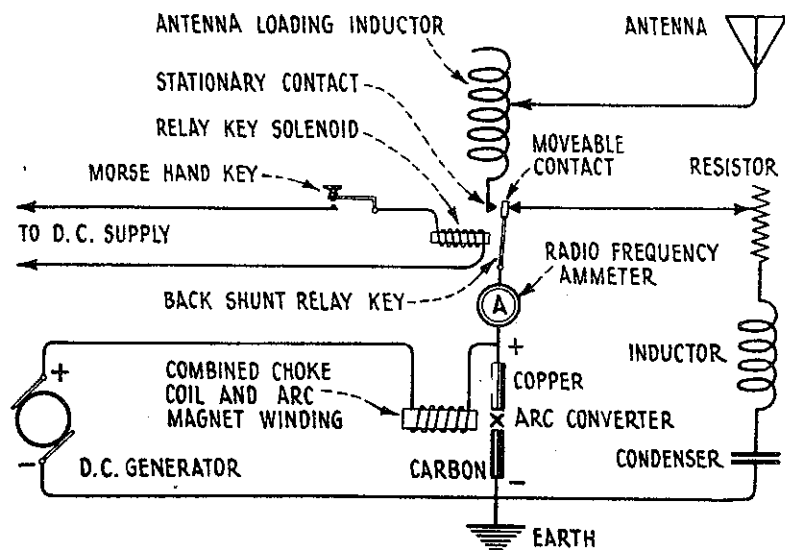


Figure 3

The back shunt circuit consists of a resistor, inductor, and condenser connected in series. The resistance of the back shunt circuit is made variable in order that the radio frequency current may be the same whether the arc is operating on the antenna circuit or the back shunt circuit.

In practice, the back shunt relay key is operated by an electromagnet, which is in turn controlled by a small Morse hand key. When the hand key is pressed down, the electromagnet is energized and the movable contact connects the arc with the antenna circuit. When the hand key is released, a spring causes the movable contact to connect the arc with the back shunt circuit. Current therefore flows in the antenna circuit only when the hand key is depressed.

Coupled Compensation Method of Signaling. The circuits used when signaling by the coupled compensation method are outlined in Figure 4. The coupled compensation loop is a single turn of cable placed around the lower end of the antenna

loading inductor. By means of the auxiliary hand key, the loop may be short circuited at the will of the operator. With the arc in operation and the auxiliary hand key open, radio frequency energy will be radiated at a certain wavelength. If the key be depressed, the energy will be radiated at a shorter wavelength than before. This change in wavelength is due to transformer action and the mutual inductance between the main coil and the short circuited loop. Radio frequency energy is thus radiated at two distinct wavelengths. The receiving station must tune to hear only the shorter wave since this is the one used to transmit signals by depressing the hand key.

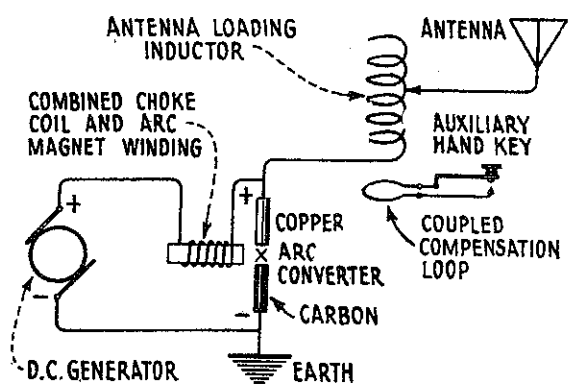


Figure 4

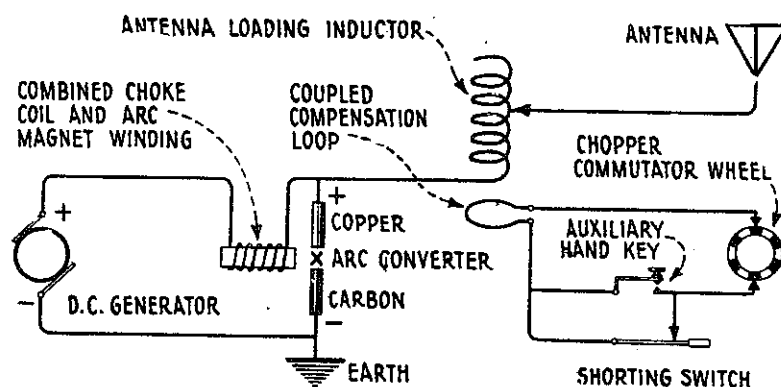


Figure 5

Signaling With Chopper. The frequency of the wave radiated by an arc radio transmitter is greater than can be heard by the human ear. In transmitting to a station which is receiving with a crystal detector, it is therefore necessary to break up the radiated energy into wave trains of an audible frequency. This is accomplished by the chopper which consists of a commutator wheel driven by a small motor.

Referring to Figure 5, the chopper commutator wheel, when rotated, opens and short-circuits the coupled compensation loop at a speed which gives a musical note in the receiver. The radio frequency energy is thus emitted at two wavelengths as when using the auxiliary hand key, but in this case the wavelength rapidly alternates between the maximum and minimum value. A continuous musical note is thus produced which may be heard by receivers using crystal detectors.

Signals may be transmitted either by means of the auxiliary hand key connected in series in the circuit between the loop and the chopper, or by means of the back shunt method of signaling. When the auxiliary hand key is used, the radiated wave is broken into wave trains of audible frequency only when the key is closed and the receiver therefore hears nothing when the key is open. When the chopper is used with the "back shunt" method of signaling, the auxiliary key is short-circuited by a small switch. The chopper is effective whenever current is flowing in the antenna circuit and signaling is accomplished by allowing current in the antenna in accordance with dots and dashes as described in the paragraphs on the back shunt methods of signaling.

Reception of Signals From Arc Radio Transmitters. The signals emitted by an arc transmitter may be either in the form of undamped radio frequency energy or undamped energy broken into wave trains of audible frequency. Receiving sets must be equipped to receive either type of signals. All signals produced by the arc without the use of the chopper are of undamped radio frequency energy, while those transmitted by using the chopper are of undamped radio frequency broken into wave trains. Transmitted signals of undamped radio frequency energy occur at such high frequencies that they are not audible in the telephone receivers of a receiving set using a crystal detector, therefore the "Heterodyne Method" is used to receive signals of undamped radio frequency energy.

The heterodyne method makes possible the reception of signals of undamped radio frequency energy by the use of the principle of beats. A local undamped current whose frequency is either slightly greater or less than that of the incoming wave is produced in the receiving set. This local current combines with the incoming energy to produce a resultant current which has a much lower frequency than either the incoming wave or the local current. It is this current, known as the "beat" current, which is audible in the telephone receivers.

Models "K" and "Q" 2 Kw. Arc Transmitters. There are two models of 2 Kw. arc transmitters to which this instruction is applicable, namely Model "K" and Model "Q". The Model "K" arc radio transmitter is for use on Naval vessels and Model "Q" is for Merchant ships. All the apparatus for the two sets is the same and the sets are identical in every way except for the range of wavelengths employed.

In the case of the Model "K" set for naval vessels, metal marking tags are supplied with the loading coil which are stamped for the standard wavelengths between 600 and 2400 meters.

In the case of the Model "Q" set for merchant ships, the metal marking tags for the loading coil are stamped with the following: 600, 750, 800, 1600, 1800 and 2300.

With the Model "K" sets the chopper is used on waves below 952 meters. On 952 meters and above, the set is operated as an undamped wave transmitter.

In the case of the Model "Q" sets for merchant ships, the chopper is used on all waves up to and including 800 meters. For the waves of 1000 meters and over, it is operated as an undamped wave transmitter.

In general, the 2Kw. arc radio set may be operated as an undamped wave transmitter on wavelengths of 950 meters and above. Below 950 meters the chopper is used.

Motor Generator for 2 Kw. Arc Transmitter. The arc of a 2 Kw. transmitter requires direct current power supplied at 250-400 volts. This is furnished by a two-bearing Crocker-Wheeler motor generator set which consists of a 100-120 v. D. C. motor, directly connected to a shunt wound, separately excited 2 Kw., 400 v. D. C. generator. The generator will deliver 2 Kw. at 250 to 400 v. and is wound for separate excitation from the 120 v. D. C. supply.

All terminals for both the motor and generator are located on an enclosed terminal board on top of the frame. Protective devices for the motor and generator are mounted inside the molded insulating cover which protects the terminal board. A diagram of connections is stamped on the terminal box and this should be carefully observed in installation.

Protective Devices. Two protective devices for the motor and generator are mounted in the terminal box on top of the unit and are connected in the circuit at all times. These are small condensers which absorb any stray radio frequency currents which may leak back into the power machinery circuits.

Motor Starter. The motor generator is started by means of a hand-operated motor starting panel. This is equipped with an overload circuit breaker which

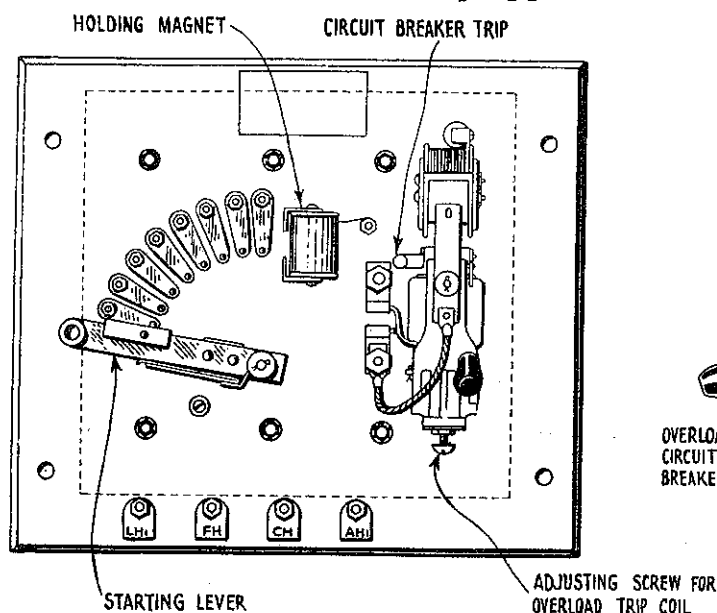


Figure 6

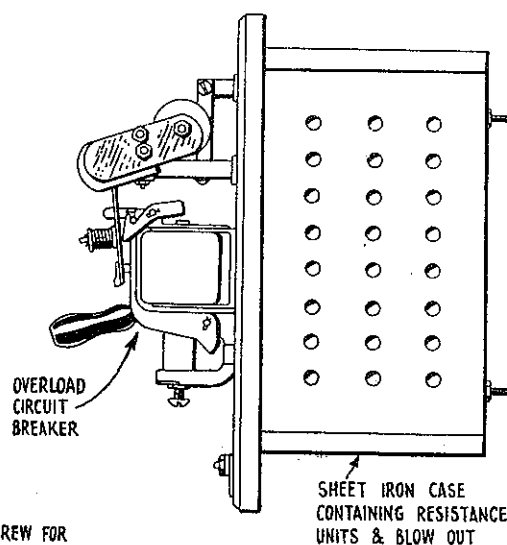


Figure 7

opens the motor supply circuit in case the current becomes excessive. The terminals on the starting panel are marked to insure proper connections. The starter is shown in Figures 6 and 7. The motor starter should always be mounted vertically to permit the circuit breaker to operate properly.

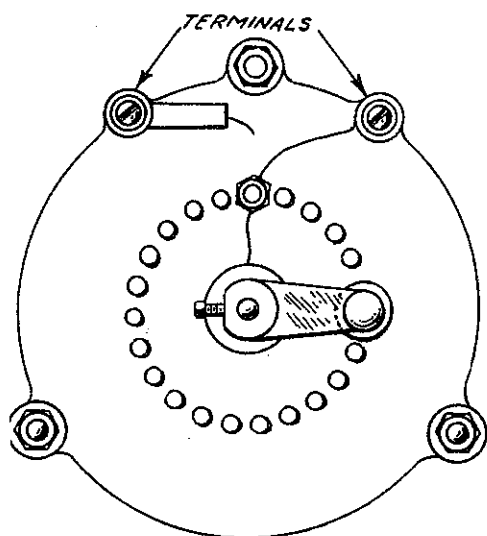
To operate the motor starter, first close the circuit breaker, then move the switch arm slowly to the right, allowing the motor to attain maximum speed on each point. When the switch arm is in running position it is magnetically locked. It will be released in case of failure of the power supply or in case the circuit breaker is opened, either by overload or by hand. The motor may be stopped by tripping the circuit breaker or by opening the set supply switch on the control panel. The starter arm will be released automatically in either case. It should never be released by hand as this would damage the contacts.

When starting the motor, the switch arm should never be returned to the starting position unless the power supply circuit is opened. Failure to observe this point will result in damaged contacts on the starter.

Generator Field Rheostat. The power output of the arc converter is regulated by adjusting the voltage of the direct current generator by means of the generator field rheostat, which is of the single plate type, shown in Figure 8. The rheostat should be installed where it can be easily reached by the operator and in a place where there is sufficient air circulation to prevent its overheating.

Arc Control Panel. The arc control panel, shown in Figure 9 is the switch-board through which connections are made between the arc converter and the direct current generator. It also carries a switch through which the entire transmitter is supplied with 110-120 v. D. C. On the panel are mounted:

- (1) The Set Supply Switch and Fuses.
- (2) The Arc Main Line Switch, with overload trip coil.
- (3) The Arc Starting Resistor and Shorting Switch.
- (4) The D. C. Ammeter for the arc circuit.
- (5) The D. C. Voltmeter for the arc circuit.



The arc main line switch is a special quick break switch which connects the arc converter to the D. C. generator. It is provided with a trip coil which opens the switch in case of overload. The switch is non-closeable on overload or short-circuit.

The arc starting resistor is connected in series between the arc converter and the D. C. generator and serves to protect the generator from sudden overloads when the arc is struck. It may be short-circuited by the starting resistor switch after the arc has been started.

The direct current ammeter and voltmeter indicate the power input to the arc.

The arc control panel is designed for wall mounting. The metal frame-work should be securely grounded through the terminal and lug supplied for this purpose. The negative terminal of the D. C. voltmeter is supplied through this ground connection.

When the handle of the arc main line switch is pushed down until it locks, the arc is connected to the generator through the ammeter and arc starting resistor. To open the switch, the operating handle should be raised until the switch trips. The arc starting resistor switch is operated in the same manner. It should be closed only after the arc has been started and is in operation. These two switches are interlocked so that both are opened whenever the arc main line switch is opened. The arc

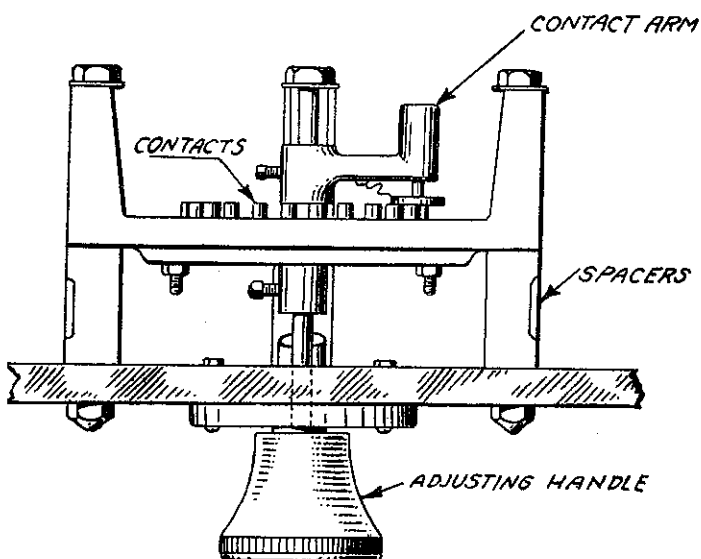


Figure 8

starting resistor is thus automatically placed in series between the arc converter and the generator whenever the main switch is opened to shut down the arc. The switches may be operated separately by opening the arc starting switch first and then the main line switch.

Care should be observed when shutting down the transmitter to open the various switches in the following order: first, the arc main line switch and starting resistor switch; and second, the set supply switch.

The arc starting resistor consists of two number D-10 Ward-Lenoard resistance tubes connected in series, giving a total resistance of 20 ohms.

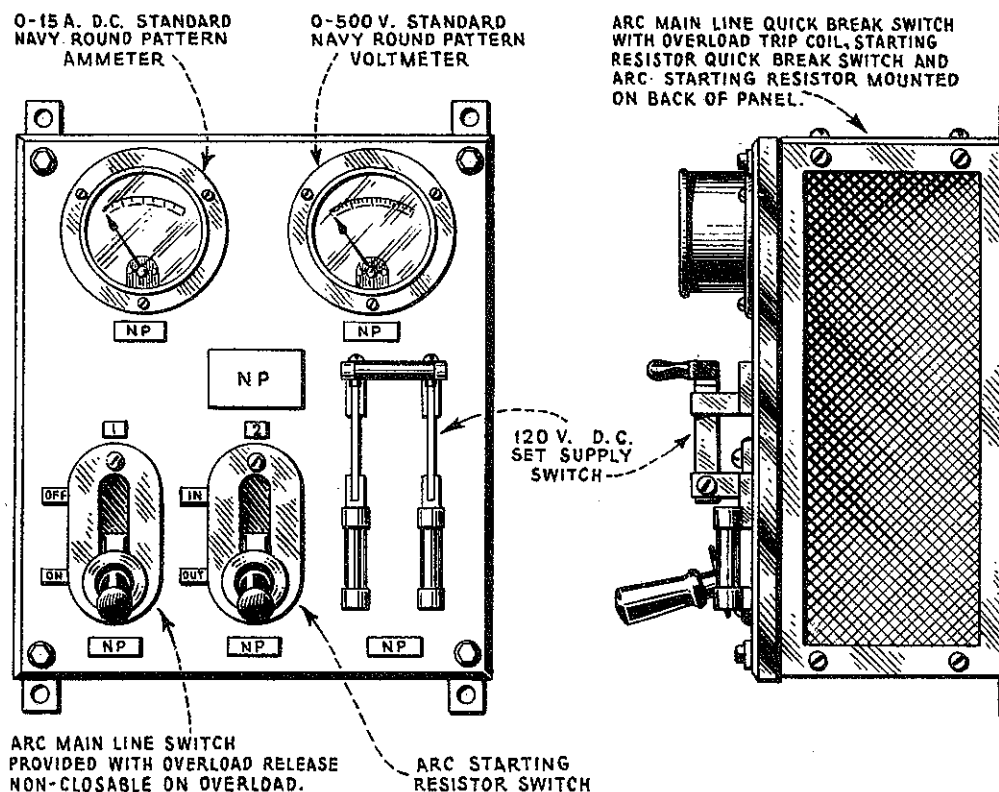


Figure 9

Arc Converter. The arc converter, shown in Figure 1 has a nominal rating of 2 Kw. The series field coils are designed to safely carry 8 amperes, direct current for 5 hours. The maximum direct current rating is 10 amperes for 2 hours.

The arc converter is designed for operation on 250 to 400 volts D. C. The voltage necessary to obtain a given antenna current on any wavelength depends upon the resistance of the antenna circuit at that wavelength.

The magnetic circuit is of the closed type. Pole tips project into the top and bottom of the arc chamber. The steel outer shell of the arc converter forms a return path for the magnetic flux.

Series Field Coils Used in Arc Chamber. The field winding is divided into four coils. Three of these are placed below the chamber and one is placed above it. All four coils are connected in series and serve both as a magnetizing winding and as choke coils to prevent the flow of radio frequency current back into the D. C. generator.

In case it becomes necessary to replace any field coil with a spare, it is highly important that the coil be inserted so that current flows through all coils in the same direction. The magnetic field must blow the arc flame toward the exhaust opening at the back of the chamber. The reversal of polarity of one coil would be sufficient to seriously impair the operation of the arc. When replacing any of the series field coils, care should therefore be taken to replace them according to instructions.

Arc Chamber. The arc chamber is a gas and water tight compartment within which the arc burns. The chamber is enclosed at the top and bottom by water cooled bronze plates. It is divided horizontally into two parts by a hinged joint, which permits the section containing the upper field coil to be lifted back. This leaves the lower part of the chamber which contains the arc electrodes easily accessible for cleaning and inspection.

The locking pin which is used for holding the upper section of the chamber open, should also always be in place when the chamber is closed to prevent any appreciable movement of the upper section should an explosion occur. The gasket between the two chamber surfaces must be kept free from dirt. Failure to do this will result in air leaks, causing a noisy, unsteady arc, and a falling off of antenna current.

All water connections must be tight since water in the arc chamber causes a decrease in antenna current and rapid wearing away of the carbon electrode.

The arc chamber should never be opened until at least one minute after the arc has been extinguished, otherwise the red hot carbon will ignite the explosive mixture which results when air combines with the chamber gases.

Anode Tip. The anode is the positive electrode of the arc. It consists of a water cooled copper tip supported by a suitable holder which is insulated from the arc chamber by means of a bakelite disc. The copper tip is brazed to a short piece of brass tubing and this unit, which is known as the anode tip, is renewable when it becomes worn after a long period of operation.

Anode Holder. The anode tip is bound to the anode holder by a small steel nut which is easily removed. The anode holder is fastened to a bakelite disc by means of a lock nut and the disc is in turn held in place in the chamber by means of a threaded locking ring. Special wrenches for the operation of these nuts and rings are included among the tools supplied with the arc converter.

Care of Anode. In operation care should be taken to see that there is always a supply of water circulating through the anode and that there are no water leaks around the anode as any water inside the chamber causes the arc to become unsteady. The bakelite disc and rubber gasket should be kept clean, otherwise the depositing of soot will ultimately form a conducting path from

the anode to the chamber and a flash-over may occur which will result in burning the bakelite disc.

Care should be taken to see that the anode tip is always properly aligned midway between the magnet poles.

The anode must always be connected through the arc series field winding to the positive terminal of the D. C. generator. If connected to the negative terminal it will melt very quickly when the arc is started.

Carbon Holder. The negative electrode of the arc is called the cathode. It consists of a carbon held in a removable holder which is, in turn, held within a mechanism which is slowly rotated by means of worm gears. The carbon is clamped in the holder by means of a split taper collet and locking nut. The holder is provided with a molded bakelite knob by means of which the portion of the holder which grasps the carbon may be screwed in and out for adjustment of the arc length.

Cathode Worm Gears. When the carbon and holder are placed in the arc converter, the carbon is slowly rotated by means of the worm gear mechanism. The worm gears are operated by means of a shaft with universal joints which connects them with another set of worm gears upon the water circulating pump. This pump is arranged so that it may be mounted on the floor directly underneath the arc converter thereby permitting the two sets of gears to be connected by the shaft and universal joints and making it possible for the motor which drives the pump to serve also as a means of rotating the arc carbon.

Alcohol Supply. The hydrogen gas which is necessary for the operation of the arc converter is supplied by the decomposition of alcohol. An alcohol cup is mounted on top of the arc converter. This is provided with a needle valve and a sight feed glass by means of which the flow may be adjusted and observed. The alcohol drips into the chamber through a hole in the upper magnet pole. When it comes in contact with the arc flame it is decomposed and a percentage of hydrogen is released.

Either grain or denatured alcohol may be used. When the arc is first started after a long period of rest, it is necessary to allow the alcohol to drip rather rapidly into the chamber; but after the arc has been running for a few minutes the rate of flow may be reduced to only a few drops per minute--only enough to maintain full antenna current and a smooth running arc.

A pressure equalizer pipe within the alcohol cup provides a passage through which gas from the chamber is permitted to reach the upper surface of the alcohol within the supply cup. This pipe insures an equal pressure above and below the alcohol and permits the use of a gravity feed.

The supply of alcohol should always be turned off whenever the arc is shut down for more than a minute or two, otherwise alcohol will be wasted and the chamber will be flooded.

Water Flow Indicator. An indicator is supplied in order that the operator may always be sure that water is flowing through the various arc cooling circuits. This consists of a small metal case with a glass front and back within

which a colored marble is placed. When water flows through the indicator, circulation is indicated by the motion and rattling of the marble.

Proper water circulation through all the various parts of the arc converter is very important and the operator should, therefore, observe the flow indicator whenever the arc is started after a long period of rest, and occasionally during operation.

Pressure Regulator. As alcohol is supplied continuously to the arc converter during operation there will always be a certain amount of gas generated within the chamber. A hose nipple is provided by means of which the excess gas may be conducted through a short piece of hose to the unit called the pressure regulator. The pressure regulator consists of an aluminum receptacle divided into two compartments by means of a rubber diaphragm. This diaphragm serves to maintain the gases within the chamber at approximately atmospheric pressure at all times. The pressure regulator is provided with an outlet through a hose nipple with a small opening. This opening permits the excess gases to slowly leak out from the regulator through a second rubber hose. This should preferably be run to some point out of doors, in order that the gases will not accumulate in the operating room.

Care of Arc Converter. The main points to be observed in caring for an arc converter are:

- (1) The chamber should be kept reasonably clean.
- (2) No water leaks, however slight, should be permitted inside the chamber. The anode tip connection and gasket should be tested whenever a new tip is installed.
- (3) The chamber should be kept air tight. The surfaces of the upper and lower chamber sections should always be clean and the gasket in good condition.
- (4) The bakelite anode insulating disc and its gasket should be kept clean.
- (5) The moving parts of the cathode should be cleaned and oiled occasionally.

Water Pump. A centrifugal water pump, shown in Figure 1 is provided for circulating water through the various water cooled parts of the arc converter. The pump is driven by a $\frac{1}{4}$ -H. P. 110 volt D. C. motor which is mounted upon an extension of the pump base and forms an integral part of the pump unit.

A set of worm gears is mounted upon the base between the pump and the motor and connected with these units, by small universal joints. These worm gears are connected by a shaft to the carbon rotating mechanism on the arc converter. This construction makes it possible to use one motor for driving both the water pump and the carbon rotating mechanism.

The pump should be mounted upon the floor underneath the arc converter. The proper method of making water connections is shown on Figure 10. A pet cock upon the pump casing provides a means of allowing the air to escape from the pump and piping and thereby priming the pump when starting for the first time.

Water Tank. A 15 gallon tank, shown in Figure 1, is provided as a container for the arc cooling water. It is necessary to use fresh water for the arc

converter in order that the anode may be insulated from earth. If salt water were used, its presence in the rubber hoses through which cooling water is supplied to the anode would furnish a relatively good conductor from the anode to the chamber and the electrodes would therefore be short-circuited.

The tank is designed so that it may be mounted either vertically or horizontally. It should be installed on the bulkhead somewhat above the level of the arc converter, in order that water may always reach the various parts of the arc, regardless of the amount of water in the tank.

The tank is provided with 3 test cocks which may be used for approximately determining the water level. The water should be renewed occasionally in order to prevent the accumulation of sediment and foreign material.

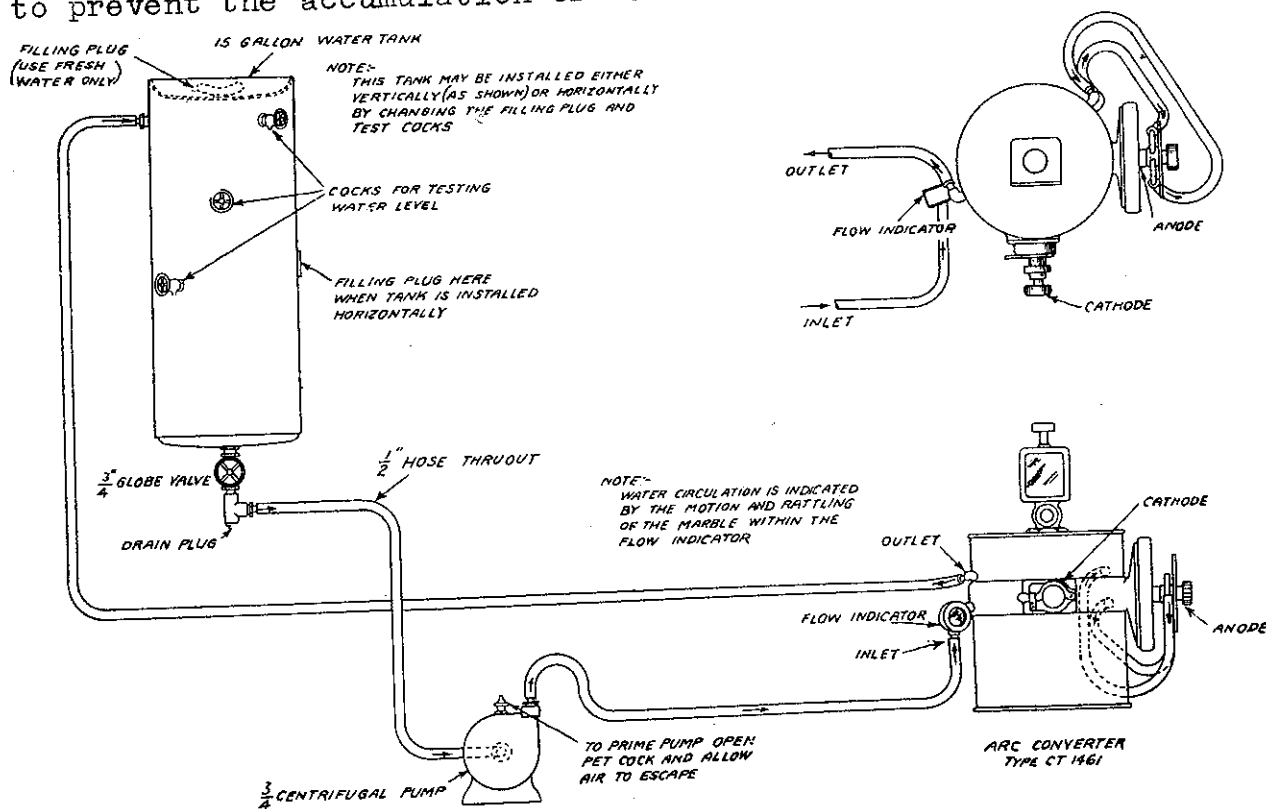


Figure 10

Antenna Loading Inductor. The antenna loading inductor, shown in Figure 1, is a coil of radio frequency cable wound upon a bakelite frame-work. It is connected in the antenna circuit between the arc converter and the series condenser from which a connection is made to the antenna. The coil is provided with taps brought out from various points in the winding for the adjustment of wavelength. When a large amount of the coil is connected in the antenna circuit, a relatively long wavelength will be secured. With a small amount of the coil in the circuit, the wave will be relatively short.

A bare copper helix is built into the lower end of the antenna loading inductor in order to provide a means of making very close adjustments of wavelength. This copper helix is used in connection with the bottom layer of the main coil. This bottom layer has 4 taps taken out at approximately equal

intervals and by making the proper connections between these taps and the bare helix, it is possible to obtain an exact adjustment for any given wavelength.

A coupled compensation loop consisting of a single turn of radio frequency cable is placed around the lower end of the antenna loading inductor. This loop provides a means of coupling the auxiliary key circuit and the chopper to the antenna circuit as described under the paragraphs relating to these units. When in operation the voltage on the upper end of the antenna loading inductor is relatively high--approximately 20,000 volts above earth potential. In installing the coil care should therefore be taken to locate it at a point where the personnel of the operating room will not come in contact with it. Care should also be taken to place the coil as far as possible from other objects and especially from iron. If the coil is installed less than about 12 inches from a steel bulkhead, a large loss of energy will occur because of the action of the high frequency magnetic field of the coil upon the iron. The special radio frequency cable with which the coil is wound makes it an inductor of very low radio frequency resistance and care should be taken to see that this advantage is not offset by improper installation. Two bakelite strips and a small bracket are furnished to support the outer end of the coil from the ceiling in case the base of the coil is mounted on the bulkhead.

Adjustment of Wavelengths. Metal tags are provided for marking the positions of the connections for all the various wavelengths upon which the set is to be operated. Two flexible conductors are supplied for making connections to the various terminals of the loading inductor. In order to make the necessary connections to obtain any given wavelength the following general procedure should be followed:

(1) Connect the clamp which is supplied for making connection to the bare copper helix to the lowest turn of this helix. Connect the other end of the cable to which the clamp is attached to the bottom-most tap on the main terminal board of the loading inductor.. This eliminates both the bare helix and the bottom layer of the coil from the antenna circuit.

(2) By means of the longer of the two flexible cables, connect the antenna series condenser with one of the upper terminals of the antenna loading inductor. If the desired wave is relatively long, this connection should be made to one of the terminals near the top of the coil. If a relatively short wave is desired, the connection should be made so that only a small portion of the coil is included in the antenna circuit.

(3) The arc may now be started and the wavelength observed by means of a wavemeter.

(4) In case the observed wavelength is too short, more layers of the coil should be included in the antenna circuit. If the wave is too long, a portion of the coil should be cut out by shifting the connection to a lower terminal.

(5) When two terminals have been found, one of which gives a wave slightly longer than desired and the other slightly shorter, connections may be made to obtain the exact wavelength by using the terminal which gives the shorter wave and then including a portion of the bare copper helix in the circuit. This is done by shifting the clamp to one of the upper turns of the

helix. In case this does not sufficiently increase the wavelength, a portion of the bottom layer of the main loading inductor may be included in the circuit by shifting the connection to one of the four taps which are brought out from this layer.

(6) After the proper positions for the various connections have been determined by trial, as described above, these positions should be permanently marked by using the stamped metal tags provided for this purpose. Three different kinds of tags are provided; one for the main terminal board of the loading coil, one for the bare helix, and another kind for the four taps in the bottom layer of the coil. The latter have celluloid surfaces upon which the wavelength should be written with India ink after the set has been tuned for the complete series of wavelengths. This method of construction is necessary for the reason that it will probably be found that several connections will be made to one terminal of the bottom layer. The tags for the bare helix should be placed beside the clamp and the clamp itself should remain upon the helix. In all cases the tags are merely a means of marking the terminals.

Radio Frequency Ammeter Panel. A radio frequency ammeter, shown in Figure 1, is supplied for indicating the current in the antenna circuit. This is a thermo-ammeter with a self-contained thermo-couple. The meter is mounted on a small bakelite panel which provides the necessary insulation between the meter and the bulkhead upon which it is installed. On the back side of this bakelite panel, a small coil of heavy copper wire is shunted directly across the terminals of the meter. This coil is called an inductive, protective shunt. Due to the high reactance of the coil, radio frequency current will take the more direct path through the ammeter, and the presence of the coil as a shunt around the meter will, therefore, not affect the reading of the instrument. In case the antenna becomes grounded or in case a direct current short-circuit occurs anywhere in the antenna circuit, the coil will take most of the direct current. It therefore serves as a protective shunt for the direct current without influencing the reading of the meter for radio currents.

Relay Key. The relay key, shown in Figure 2, provides a means of connecting the arc either to the antenna circuit or to the local "back-shunt" circuit at the will of the operator. It consists of a movable contact which is controlled by an electromagnet and a spring. When the operator presses downward upon the Morse hand key, the electromagnet is energized and the movable contact then connects the arc converter to the local "back-shunt" circuit. The two stationary contacts through which these connections are made are so arranged that the connection with one circuit is made before breaking the connection to the other circuit. This is accomplished by the use of springs and adjusting screws.

The relay key may be installed either on the bulkhead or on the operator's table. Since it is provided for electromagnetic control by means of the Morse hand key, it need not be located at a point which is within reach of the operator. It should be placed, however, where it may be easily inspected, cleaned and adjusted.

In adjusting the relay key, care should be taken to see that the movable contact makes connection with one stationary contact before it breaks with the other. The amount of motion of the contacts during this period of common connection should be about $1/32"$ to $1/16"$. The amount of break between the contacts when they are open should be about $1/16"$. After the key has once been carefully adjusted it should require very little further attention with the exception of an occasional brightening of the contact with sand-paper. A small amount of oil on the moving parts will insure long life and prevent their sticking.

A series resistance for the relay key solenoids is mounted directly on the base of the key. This resistor is a number B-350 Ward-Leonard tube. When this resistance and the two solenoids are all connected in series, the proper current is obtained by supplying the key with 110-120 v. D.C. through the Morse hand key.

Back Shunt Circuit Unit. A local, non-radiating oscillatory circuit is supplied in order that the arc converter may have a circuit upon which to

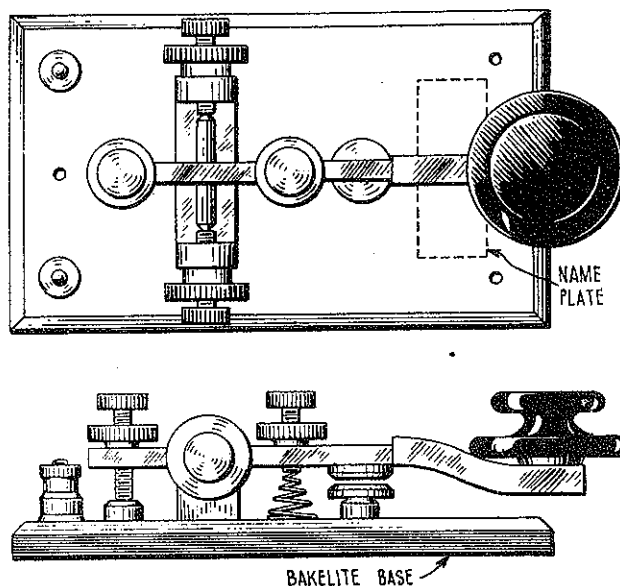


Figure 11

oscillate during the intervals between dots and dashes. This local circuit is called the "back shunt" circuit, for the reason that it is shunted around the arc when it is desired to exclude current from the antenna.

Transfer Switch for Chopper and Auxiliary Hand Key. A single pole, double throw transfer switch is supplied in order that the coupled compensation loop around the bottom of the antenna loading inductor may be connected either to the chopper or the auxiliary hand key or to the two in series. A name plate is supplied with this switch which may be mounted with it in order to indicate the proper position of the switch for each circuit combination. A wiring diagram of the coupled compensation circuit is included on this name plate. When this switch is thrown to the right, the coupled compensation loop is connected directly with the auxiliary hand key. Signaling may then be accomplished by the coupled compensation method.

When the switch is thrown to the left the chopper is connected directly to the coupled compensation loop. Signaling with the chopper may then be accomplished by the use of the back shunt relay key.

With the switch open the auxiliary hand key is connected in series with the compensation loop and the chopper. Signals may then be transmitted with the chopper by using the auxiliary hand key.

Chopper. The chopper, shown in Figure 1, consists of a commutator wheel driven by a $\frac{1}{4}$ -H. P. 110 v. D. C. motor. Segments of the commutator wheel are connected at regular intervals to a central ring. The chopper brushes are so adjusted that they both make contact with these connected segments at regular intervals during the rotation of the wheel. The two brushes are connected through a suitable switch to the coupled compensation loop which is placed around the bottom of the antenna loading inductor. The commutator wheel serves to alternately open and short-circuit this coupled compensation loop. When the compensation loop is open, energy is radiated at a given wavelength. When the commutator wheel is in a position which short-circuits the compensation loop, energy is radiated at a slightly shorter wavelength.

Auxiliary Hand Key. The auxiliary hand key, shown in the diagram Figure 11, is supplied in order that signaling may be accomplished by the coupled compensation method whenever desired and in case of failure of the back shunt method of signaling.

Note Varying Variometer. The tuning with an arc radio transmitter is very sharp and in case an arc set is calling a station whose receiver is not tuned exactly, the call may not be heard. In order that the operator may be able to slightly vary the length of his outgoing wave while calling, a Note Varying Variometer is supplied. This variometer, shown in Figure 1, consists of a stationary coil and a coil which may be rotated within the stationary coil. When the rotating coil is turned in one direction, the out-going wave is lengthened; and when it is turned in the opposite direction, the wave is shortened. By rotating this coil slightly, first in one direction and then in the other, the operator is able to slightly vary the out-going wave and thereby make his call heard by the receiver.

A notching device built into the variometer holds it in a central position except when it is moved from this position by the operator. The variometer is connected directly in series in the antenna circuit between the antenna loading inductor and the relay key. It may be mounted either on the table or on the bulkhead as desired.

Antenna Low Power Resistor. In order that the antenna current may be reduced when communicating with anearby station, a resistor, shown in Figure 1, is supplied which may be connected in series in the antenna circuit for operation on low power. This consists of two Ward-Leonard resistance tubes supported on a suitable frame. A shorting switch is mounted near the unit. This switch is closed except when it is desired to operate on low power. The antenna low power resistor is connected in series in the antenna circuit between the arc converter and the radio frequency ammeter.

Send-Ground-Receive Switch. This switch, shown in Figure 1, provides the means of connecting the antenna either to the transmitter or to the receiver, or to ground. It consists of a cast iron base upon which suitable insulators and standards are mounted. The insulators are made of bakelite and are practically non-breakable. The high voltage parts have brass shields made with a radius curvature which prevents corona. The ground and receive positions are mounted within a protective hood which prevents a flash-over between the high voltage parts and the receiving clip.

Interlock contacts are provided on the Send- Ground-Receive Switch for the 110 v. D. C. circuit which supplies the relay key and other auxiliaries.

The Send-Ground-Receive switch may be mounted either on the bulkhead or on the table, wherever it is within convenient reach of the operator and where the radio frequency connections may be conveniently made. Ample clearance should be allowed around all high voltage parts and care should be taken to place it where the danger of the personnel coming in contact with it is minimized.

Morse Hand Key. This is a Morse hand key of the usual radio telegraph type, Figure 1. By means of it, the relay key is controlled and signaling is accomplished by the back shunt method.

Antenna Series Condenser. This is a mica condenser mounted within a suitable box as shown in Figure 1. It is connected in series in the antenna circuit on all wavelengths below 2000 meters and is placed in the circuit between the Antenna Loading Inductor and the Send-Ground-Receive switch. The capacitance of the series condenser is 0.0006 mfd. and it therefore considerably reduces the effective capacitance of the antenna circuit. This permits the use of more antenna loading inductance than could otherwise be used for any given wavelength. The increase of inductance and decrease of capacitance insures steadier operation of the arc converter, especially when used as an undamped wave transmitter on wavelengths between 950 and 2000 meters. For waves over 2000 meters the series condenser is shorted out of the circuit by means of a switch mounted upon its terminals.

The condenser is mounted at a point where there is minimum danger of the personnel of the operating room coming into contact with its high voltage terminals. The condenser has bakelite legs which provide insulation between it and earth. The metal angles at the bottom of these legs are grounded.

Operation of Model K or Q 2 Kw. Arc Radio Transmitter. Before starting the set for the first time, the various circuits should be tested to see that all electric connections have been made in the proper manner. The following steps should also be taken:

- (1) Fill the alcohol cup and see that it feeds properly.
- (2) Fill the water tank $\frac{3}{4}$ full with fresh water.
- (3) See that the valves of the water tank are open and that the flow indicator indicates a circulation of water when the pump is started.
- (4) See that all moving parts are properly lubricated.

To start the set after a long period of rest:

1. Close the set supply switch.
2. Place the Send-Ground-Receive Switch in the sending position. This should start the water pump and the carbon rotating mechanism which are supplied through interlock contacts.
3. Start the motor generator by closing the circuit breaker on the starting panel and bring the motor gradually up to full speed. Adjust the generator voltage to about 250 volts by means of the field rheostat.
4. Start the alcohol flowing so that it drips rather rapidly. Adjust the carbon on the arc so that there is about 1/32" motion when the arc is struck.
5. Close the arc main line switch and strike the arc. Draw it out as long as possible without causing it to break. In starting for the first time, it will be necessary to keep the arc rather short for a minute or two until sufficient alcohol has been decomposed to give a partial hydrogen atmosphere in the chamber. As soon as the arc starts oscillating, the radio frequency ammeter will indicate current in the oscillatory circuit and the arc should then be adjusted to obtain a maximum reading of this meter.
6. Close the arc starting resistor switch and adjust the arc for a maximum reading of the radio frequency ammeter. The alcohol flow may now be reduced to a few drops per minute and the generator voltage adjusted to obtain the desired antenna current.

To Transmit Signals. After the arc is operating, signals may be transmitted by sending with the Morse hand key. In case radio frequency current through the back shunt circuit differs materially from that in the antenna circuit the resistance of the back shunt circuit should be adjusted so that the output of the arc converter is the same for both circuits.

Arc Adjustment. After the arc is in operation, it will only be necessary to make occasional slight adjustments of arc length. These adjustments are made to obtain a maximum reading of the radio frequency.

Only enough alcohol should be used to obtain full antenna current.

If the arc breaks or goes out it will be necessary to open the arc starting resistor switch and strike the arc again. In case the arc is struck without opening this switch, a short circuit will result and a trip coil will open the arc main line switch. It is then necessary to lift the handle of this switch to the upper position and reclose it; then strike the arc and reclose the starting resistor switch.

To stop the arc for a short period:

1. Open the arc main line switch (this automatically opens the arc starting resistor switch).
2. Put the Send-Ground-Receive Switch in the receiving position.

If it is desired to stop the motor generator, this may be done by opening either the set Supply Switch or the circuit breaker on the motor starting panel.

To start the arc after a short period of rest:

1. Put the Send-Ground-Receive Switch in sending position and start

the motor generator if it has been stopped.

2. Close the arc main line switch, strike and adjust the arc.
3. Close the arc starting resistor switch and adjust the arc.

To shut down the set for a long period of rest.

1. Open the arc main line switch.
2. Open the set supply switch (this automatically releases the arm of the motor starting panel by means of the low voltage release coil).
3. Cut off the alcohol flow.
4. Place the Send-Ground-Receive Switch on send or ground as desired.

To use the chopper with the back shunt method of signaling. When it is desired to transmit signals on waves shorter than 950 meters by means of the chopper, the following procedure should be observed:

1. Throw the single pole double throw transfer switch to the left and close the double pole switch mounted on the chopper, thereby connecting the chopper to the coupled compensation loop on the loading coil.
2. Start the chopper motor by closing the snap switch.
3. Start the motor generator and arc converter in the usual manner.
4. Signals may now be transmitted by using the Morse hand key and back shunt circuit in the usual manner.

To use the chopper with the auxiliary hand key.

1. Open the single pole, double throw transfer switch. Close the double pole switch mounted on the chopper and start the chopper motor by the snap switch.
2. Connect the arc to the antenna circuit by closing the shorting switch on the Morse hand key.
3. Start the motor generator and arc converter in the usual manner.
4. Signals may now be transmitted with the chopper by using the auxiliary hand key.

To transmit undamped wave signals by means of the auxiliary hand key. When it is desired to send signals, using the auxiliary hand key without the chopper:

1. Throw the single pole double throw switch to the right hand position, thereby connecting the auxiliary hand key directly to the coupled compensation loop on the antenna loading inductor.
2. Connect the arc converter to the antenna circuit by closing the shorting switch on the Morse hand key.
3. Start the motor generator and arc converter in the usual manner.
4. Signals may now be transmitted by the coupled compensation method with the auxiliary hand key.

To change wavelength.

1. See that the arc converter is shut down.
2. Change the antenna connection on the loading inductor to the terminal which is marked for the new wave.

3. Change the connection between the bare copper helix and the taps in the bottom layer of the loading inductor to the positions which are marked for the new wavelength.

EXAMINATION - LESSON 58

1. Which electrode of the arc rotates and why?
2. How would you gauge the correct flow of alcohol in the arc chamber?
3. How is the power output of the arc regulated?
4. Name the principal parts of an arc transmitter.
5. What is the purpose of the chopper?
6. What might happen if the arc chamber were opened immediately at the close of transmission?
7. How is hydrogen gas obtained in the arc chamber?
8. How would you determine if water was circulating through the arc cooling circuits?
9. What care should be observed when shutting down the transmitter?
10. What is the form of the wave emitted by an arc transmitter?